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Morphometric study of fourth ventricle indices in normal subjects by computed tomography

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Abstract
Aim: The present study aimed to find range of fourth ventricle indices, their variation with age and gender in apparently normal subjects.
Material and Methods: With the Institutional ethical committee clearance, soft copies of head CT scans of two hundred subjects (96 males, mean age 38.31 ± 14.16 yrs., and 104 females, mean age 36.36 ± 16.74 yrs.) were subjected to morphometric analysis of fourth ventricle's height and width using dicom image software. Mean, standard deviation, ranges were calculated. Two sample independent student t -test, Pearson's correlation coefficient and Regression analysis were applied to find the gender variation.
Results: The 4th ventricle height of all subjects ranged from 6-12 mm with mean (± SD) 8.96 ± 1.24 mm and median 9 mm. In females, it ranged from 6-12 mm with mean (± SD) 8.59 ± 1.20 mm and median 9 mm while in males, it ranged from 7-12 mm with mean (± SD) 9.36 ± 1.17 mm and median 9 mm. The mean of 4th ventricle height of males was comparatively higher than females. Comparing the mean of 4th ventricle height between two groups, Student's t test showed significant difference and higher (8.3%) height in males as compared to females (8.59 ± 1.20 vs. 9.36 ± 1.17, t=4.64, p<0.001). Similarly, the 4th ventricle width of all subjects ranged from 6-13 mm with mean (± SD) 9.79 ± 1.19 mm and median 10 mm. In females, it ranged from 6-12 mm with mean (± SD) 9.39 ± 1.14 mm and median 9 mm while in males, it ranged from 8-13 mm with mean (± SD) 10.21 ± 1.09 mm and median 10 mm. The mean of 4th ventricle width of males was comparatively higher than females. Comparing the mean of 4th ventricle width between two groups, Student's t test showed significantly different and higher (8.0%) width in males as compared to females (9.39 ± 1.14 vs. 10.21 ± 1.09, t=5.13, p<0.001) The 4th ventricle width of all the subjects was comparatively higher than the height of the 4th ventricle in both the genders and was more in males as compared to females.

Keywords: morphometric, ventricle, tomography, computed, comparatively

Introduction
The fourth ventricle is a midline cavity which is diamond shaped in the frontal projection and triangular in lateral cross section. The measurement of the fourth ventricle is 1.6 cm from the fastigium to the floor and 4 cm from the superior to the inferior angle. It communicates superiorly with the third ventricle by means of the cerebral aqueduct, and antero-inferiorly with the central canal of the medulla oblongata. Below in the midline and laterally in the lateral recesses it communicates with the cisterna magna (cerebellomedullaris) by the foramen of Magendie and Luschka respectively [1]. The fourth ventricle possesses lateral boundaries, a roof, and a rhomboid shaped floor. The caudal part of each lateral boundary is formed by the inferior cerebellar peduncle [2]. The cranial part of each lateral boundary is formed by the superior cerebellar peduncle. The tent shaped roof projects into the cerebellum. The superior part is formed by the medial borders of the two superior cerebellar peduncles and a connecting sheet of white matter called the superior medullary velum. The inferior part of the roof is formed by the inferior medullary velum, which consists of a thin sheet devoid of nervous tissue [3] and formed by the ventricular ependyma and its posterior covering of piamater. This part of the roof is pierced in the midline by a large aperture, the median aperture or foramen of Magendie [4]. Lateral recesses extend laterally around the sides of the medulla and open anteriorly as the lateral openings of the fourth ventricle, or through foramina of Luschka. Thus the cavity of the fourth ventricle communicates with the subarachnoid space [5] through a single median opening and two lateral apertures. These important openings permit the cerebrospinal fluid to flow from the ventricular system into the subarachnoid space. It is present in posterior cranial fossa between the pons and medulla ventrally and cerebellum dorsally, thus it becomes difficult to visualize during routine head CT study. Its dimensions may change with intracranial hypertension, psychiatric alterations [6], hydrocephalus [7], epilepsy, meningoencephalitis, migraine, spinal cord injuries and neurocysticercosis [8]. Further, it is important to distinguish between obstructive and communicating hydrocephalus. In acute obstructive hydrocephalus, external ventricular drainage remains the treatment of choice whereas patients with communicating hydrocephalus can be managed by lumbar puncture [9] alone which is less risky. Size of ventricles in such cases may be of some help to come to a conclusion. In past some researchers have reported width of fourth ventricle to be greater than its height [10, 12], and both width and height being higher in males than in females. Though the width is always measured in axial views. In this study we have correlated the fourth ventricle height and width.

Material and Methods

The study group was drawn from patients reporting to the department of Radiology and Imaging, Motilal Nehru Medical College Allahabad, for a head CT examination for various indications between October 2016 to April 2017. The study was conducted in the department of Anatomy, Motilal Nehru Medical College, Allahabad. Study Design: It was an observational and cross sectional study. Sampling: Soft copies of virtually normal head CT scans of total two hundred patients were selected for the measurements for the purpose of this work. Ninty six patients were males and one hundred four were females. Inclusion criteria: The patients of both sex and age group from 01 year to 60 years, with virtually normal head CT scan were included in the study. Only CT scans interpreted normal by experienced radiologist were included in this study. Exclusion criteria: CT scans showing gross pathological changes affecting the normal anatomy of ventricles (e.g. due to large metastasis etc.) were excluded from the study group. Ethical considerations: Before starting the work on the project, study protocol was submitted to the institutional ethical committee of Motilal Nehru Medical College and the approval was taken for the same. CT study: All patients had undergone axial transverse scanning of the brain performed on available multi slice CT scanner. The scans were obtained on a plane at an angle of 15 degree to and 1cm above the infraorbitomeatal line. All other technical parameters of the scans were as per the established standards. (e.g. time in ms, potential in k v, current in m A) and slice thickness of 5 mm. Images for the study were selected out of the routinely done investigations. No extra scans were indicated for the purpose of this study to avoid unnecessary radiation exposure. Image selection**:** For the present study two images were selected for each patient. Axial image at the level of fourth ventricle a) Greatest height of fourth ventricle in mm, which can be measured from the upper margin of the pons to the lower limit of open part of medulla oblongata. b) Greatest width of fourth ventricle in mm which is the distance between roof and floor of the fourth ventricle.

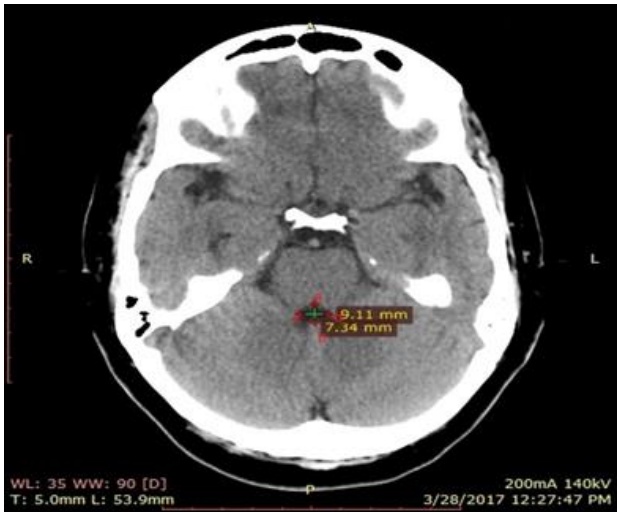


Fig 1: Scan at the level of fourth ventricle in female, (a-b) = height of fourth ventricle in mm**,** (c-d) = width of fourth ventricle in mm.

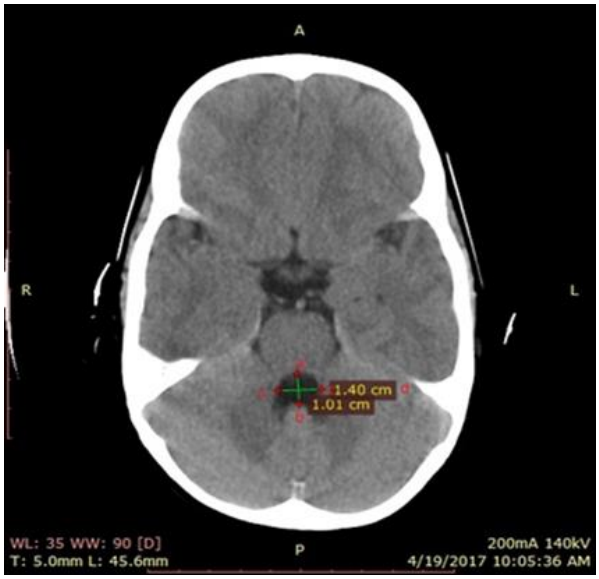


Fig 2: Scan at the level of fourt ventricle in male, (a-b) = height of fourth ventricle in cm. (c-d) = width of fourth ventricle in cm.

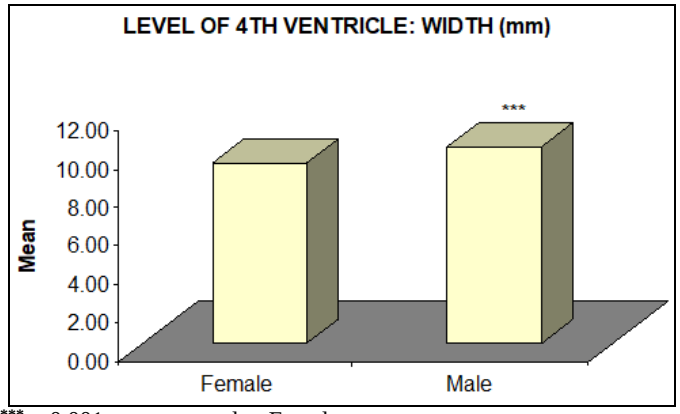
Results

The height of 4th ventricle of all subjects ranged from 6-12 mm with mean (± SD) 8.96 ± 1.24 mm and median 9 mm. In females, it ranged from 6-12 mm with mean (± SD) 8.59 ± 1.20 mm and median 9 mm while in males; it ranged from 7-12 mm with mean (± SD) 9.36 ± 1.17 mm and median 9 mm. The mean of 4th ventricle height of males was comparatively higher than females. Comparing the mean of 4th ventricle height between two groups, Student's t test showed significant difference and higher (8.3%) height in males as compared to females (8.59 ± 1.20 vs. 9.36 ± 1.17, t=4.64, p<0.001). Similarly, the 4th ventricle width of all subjects ranged from 6-13 mm with mean (± SD) 9.79 ± 1.19 mm and median 10 mm. In females, it ranged from 6-12 mm with mean (± SD) 9.39 ± 1.14 mm and median 9 mm while in males; it ranged from 8-13 mm with mean (± SD) 10.21 ± 1.09 mm and median 10 mm. The mean of 4th ventricle width of males was comparatively higher than females. Comparing the mean of 4th ventricle width between two groups, Student's t test showed significantly different and higher (8.0%) width in males as compared to females (9.39 ± 1.14 vs. 10.21 ± 1.09, t=5.13,

p<0.001) (Table 2 and Fig.3). The 4th ventricle width of all the subjects was comparatively hig8her than the height of the 4th ventricle in both the genders and was more in males as compared to females.

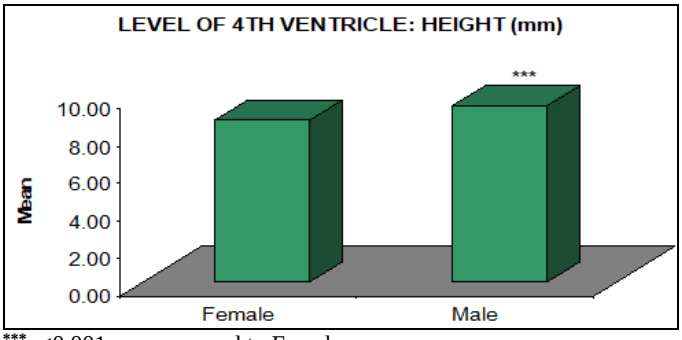
Table 1: Level of 4th ventricle (Mean ± SD) of two groups.

Level of 4th ventricle	Females (n=104)	Males (n=96)	Total (n=200)	T value	P value
Height (mm)	8.59 ± 1.20	9.36 ± 1.17	8.96 ± 1.24	4.64	<0.001
Width (mm)	9.39 ± 1.14	10.21 ± 1.09	9.79 ± 1.19	5.13	<0.001



***p<0.001- as compared to Female

Fig 3: Mean of 4th ventricle width of two groups.



***p<0.001- as compared to Female

Fig 4: Mean level of 4th ventricle height of two groups.

Table 2: Correlation (r value) of ventricular system of the brain with age.

Parameter	Variable	Female (n=104)	Male (n=96)	Total (n=200)
Level of 4th ventricle	Height	-0.10ns	-0.14ns	-0.09ns
	Width	0.20*	-0.10ns	0.09ns

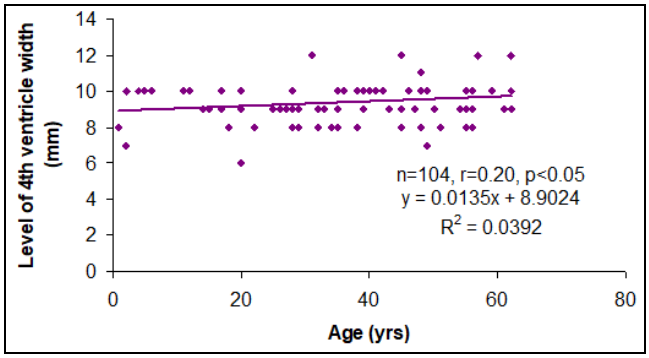


Fig 5: Scatter plot showing linear relation between width of 4th ventricle and known age of females (n = 104).

Discussion

Ventriculomegaly is commonly observed in most of the neurodegenerative disorders [13], like Alzheimer's disease, dementia, major depression [14], multiple sclerosis, schizophrenia [15] etc. This results in passive enlargement of lateral, third, and fourth ventricle along with shrinkage of brain parenchyma [16]. However the findings in these diseases are non- specific. Now a days, the study of various morphometric parameters of the brain ventricle is not only important for anatomists but also for radiologists and neurosurgeons for evaluating changes due to growth, ageing [17, 19], intrinsic and extrinsic pathologies and also for the localization and removal of space occupying lesions around ventricular system like gliomas, craniopharyngiomas. Fourth ventricle is enlarged in brain stem tumors [20], blockage of foramen of luschka and Magendie, Arnold Chiari malformations, autism, etc. In the context of increased brain ventricle size seen in routine clinical practices knowledge of normal range of precise measurement is needed before taking the appropriate decisions for further management. According to the opinion of Gawler (1976) [21], the greatest height between roof and the floor of the fourth ventricle was 10.8 mm. In the present study it was 8.96 mm. Gawler found that the height of the 4th ventricle was higher in males as compared to females. In the present study the height of the 4th ventricle was found to be significantly (p≤ 0.001) higher in males (9.36 mm) as compared to females (8.59 mm). This is similar to the result reported by Gawler. D'souza and Natekar (2007) [22] observed that the height of the fourth ventricle was significantly larger in males (11.8 ± 2.7 mm) as compared to females (11.1 ± 2.4 mm). The width of the fourth ventricle was found to be greater than the height in both gender and was more in males (13.1 ± 2.3 mm) than in females (12.1 ± 2.4 mm). In the present study the greatest height in males (9.36 ± 1.17 mm) was more than in females (8.59 ± 1.20 mm). The

width was more than the height and was more in males (10.21 ± 1.09 mm) than in females (9.39 ± 1.14 mm). This is similar to the result reported by D'souza and Natekar.

Table 3: Comparison of the 4th ventricle height and width with other studies.

Parameters	Gawler *et al.* (1976)	D'souza and Natekar (2007)		Present study	
Height		Male	Female	Male	Female
Mean	10.8 mm	11.8mm	11.1 mm	9.36mm	8.59mm
SD	-	± 2.7	± 2.4	± 1.17	± 1.20
Width					
Mean	-	13.1 mm	12.1 mm	10.21 mm	9.39 mm
SD	-	± 2.3	± 2.4	± 1.09	± 1.14

Conclusion

Evaluation of the normal measurements of the cerebral ventricles in the living human has great importance in the diagnosis and monitoring of several pathologies [23, 24]. CT scanning on normal subjects helps to visualize the ventricles of the brain, and their overall configuration can be well reconstructed from a series of contiguous slices [25]. Morphometric studies of human brain ventricles have been under focus by many scholars recently due to it is relation with pathological evidences such as hydrocephalus, schizophrenia, tumors, trauma etc. as well as gender and aging which could lead to dementia and or brain geriatric changes [26]. In our computerized tomographic study of ventricular system of brain in 200 subjects, we concluded the following: With increasing age, there is increase in all ventricular parameters, which was most profound in the sixth and seventh decades. The height of the fourth ventricle is significantly higher (p=<0.001) in males as compared to the females. The width of the fourth ventricle is higher than the height, and it was significantly higher (p=<0.001) in males as compared to the females.

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